Chess

How many steps in this problem?

What volume of 1.0 M hydrochloric acid
would react with exactly 10.0 g of chalk?

4 to 5

reported by faculty, grad students, chem majors, PLTL leaders

How many steps for novice?

M = moles per liter

Hydrochloric is HCl

Chalk is calcium carbonate

Calcium is Ca, and 2+

Carbonate is CO_3^{2-} , and 2-

A reaction occurs

Reactants are CaCO3 and HCl

Products are not important to the problem

Balance the reaction

Reactions are based on moles

Formula Wt of CaCO3 comes from periodic table

Add elements = 100 g/mole

Calculate moles CaCO3 using mass and FW

Use stoiciometry to convert moles to HCl

“exactly” means stoichiometric amount

Calculate volume from moles and M

I’m done

What does it mean to be an expert?

You grow increasingly larger ‘chunks’ of related information in long term memory.

This allows you to work on more complex problems in working memory.

Where and how is learning happening in the brain?

Neuroscience

- Learning changes the structure and function of the brain (neural networks, synaptic growth, neurons that fire together wire together)
- If you have an “aha” moment today, I can tell you where that happens.

What does is mean to *know* something?

Epistemology

Lower stage

There is right and wrong. An authority should knowing the answers. Learning means finding what's right from authorities, remembering it, and demonstrating ability to recall that on a test.

Advanced stage

There is legitimate uncertainty, context matters, and evidence is weighed to reach conclusions through logical argumentation. Learning means making a commitment despite uncertainty.

What does it mean to learn or to become an expert?

Reasoning Processes

- Moving concrete to abstract benefits all learners
- Large fraction of incoming college students have difficulty with ratio/proportion, control of variable/inference, combinatorial organization, trains of thought
- Metacognitive self-regulation, awareness and reflection on one's own thinking
- Analogic mapping is important step for learning transfer

No person is an island
Social Dynamics

- Articulation promotes learning
  - Explanatory dialogue promotes learning (to self, with others, with computer)
- Effective learning-group structure
  - Positive interdependence of goals, roles, resources, rewards; Face-to-face interaction; Individual accountability; Group skill development; Assessment of group

Why bother?
Cognitive Motivation Theory

- Competence breeds confidence.

  Rewards and praise for performance (not simply good feelings) lead to enhanced self-efficacy

- Attribution of a failing performance to uncontrollable stable personality traits undercuts motivation

- Intrinsic is better (challenge, curiosity, control, fantasy)

Pintrich, P.R. & Schunk, D.H. (1996)
Motivation in Education: Theory, Research, and Applications, Columbus, OH: Prentice Hall

Take away

If you are going to do something
in the classroom,
you should have a reason.

Some reasons are better than others.

UNH Inquiry Courses

Characteristics

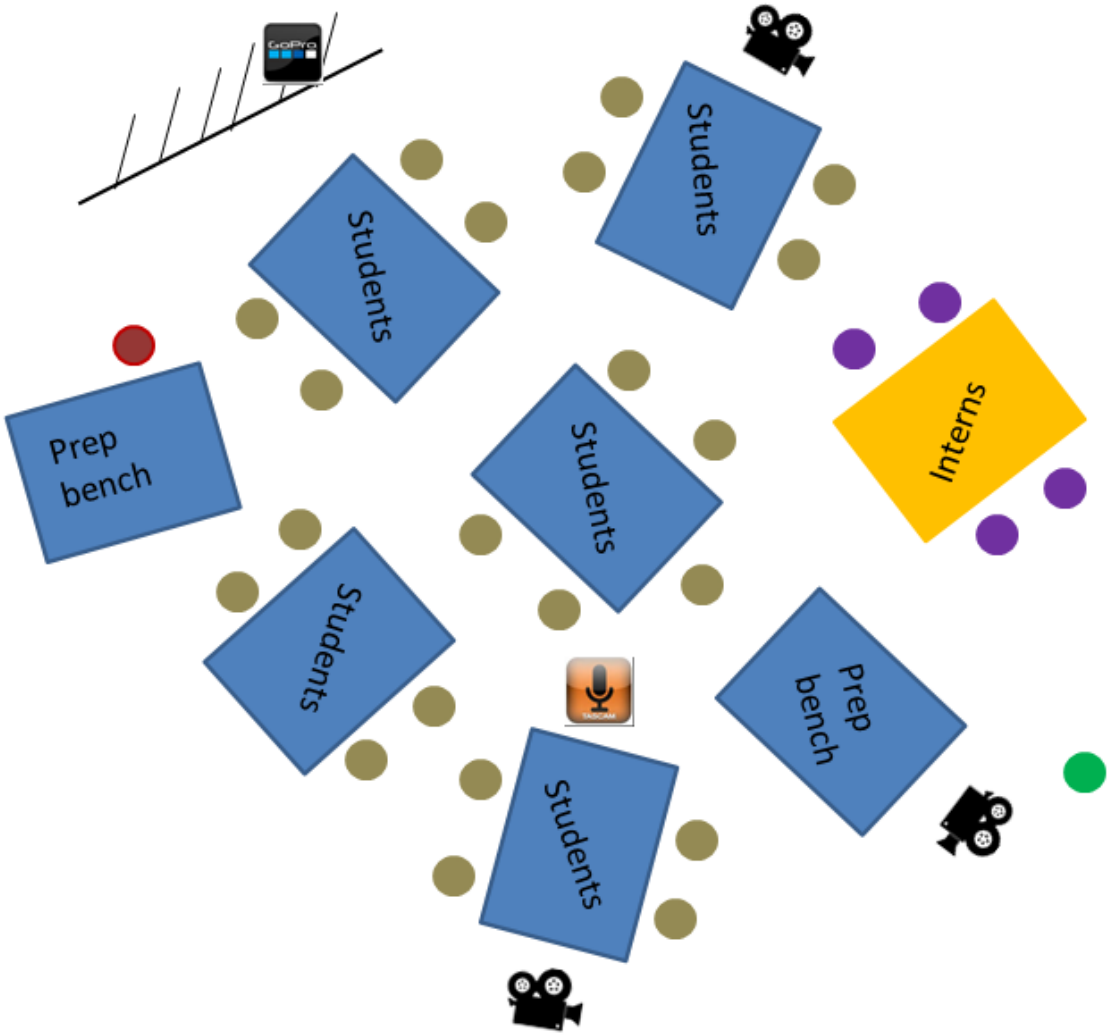
- single topic
- multiple perspectives
- experiential learning
- small

Intellectual Goals

- become active, independent thinkers
- reflect on their learning processes
- articulate and present results
- develop their own strategies

Student inquiry into heat

Classroom Layout



- researcher
- Instructor
- Interns
- students

GoPro camera

Tascam

video-camera

Student focus groups

- I found the course content very interesting and engaging. This class was very different than any other class I've taken. The information was presented effectively through group discussion and this interaction allowed a higher level of understanding to be achieved.
- I learned a lot, not only about heat, but also about working with teams, and about myself.
- It was a nice change to not be lectured to for eighty minutes and to get to know my peers.

Nature of Science

" I didn't have any questions in the first place. I was fine not knowing about these things. Now I wonder …"

"…how much does culture affect science?"

"…are 'Phlogiston Theories' all around us today."

" Scientists had to redefine everything."

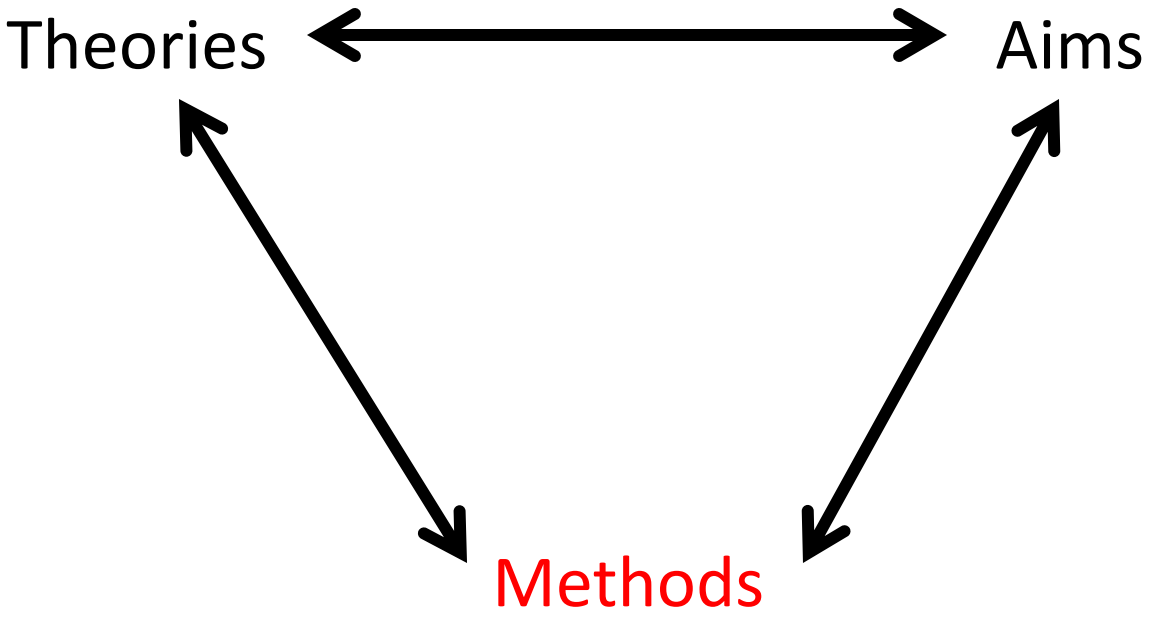
" It shows that creativity is an important skill …"

".. a majority [of scientists] are trapped by a lack of funding."

Inquiry models can help create learning environments that

- Support knowledge construction – more cognitive involvement more of the time
- Build self-efficacy (and motivation)
- Elicit and address conceptual misconceptions
- Rely on articulation of understanding
- Represent science realistically as evidence-based exploration and collaboration

Laudan (‘84), via Duschl (‘90), via Abrams & Wandersee (‘95)

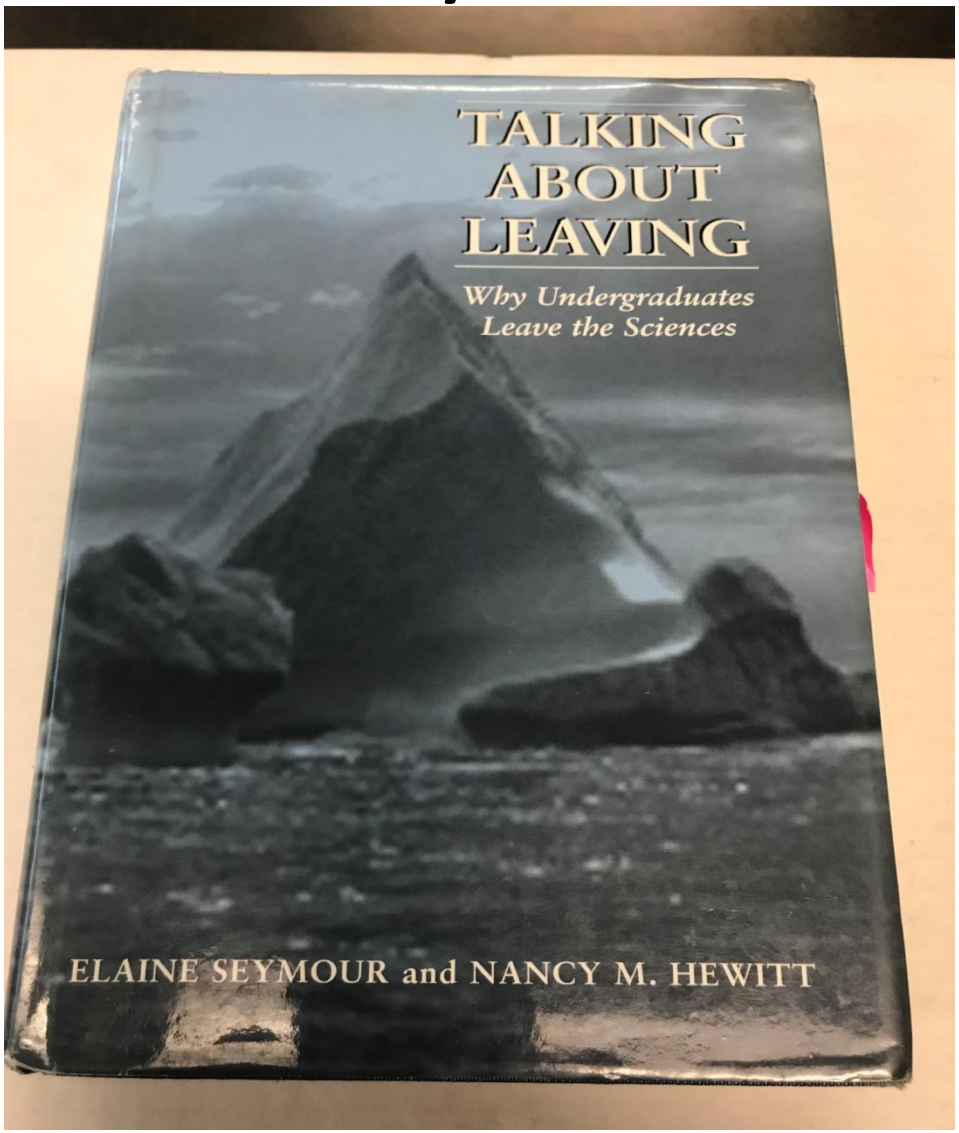


Triadic model for the growth of scientific knowledge

Methods

Stop relying on course examinations and grades as sole output variable

E. Seymour, N. Hewitt, 1997



Hold up

Blue 7-8

Yellow 5-6

Green 3-4

Red 0-2

Methods

- Observe, listen, and describe experience richly
  - Tobias “They’re Not Dumb; They’re Different”
  - Seymour & Hewitt “Talking about Leaving”
  - Classroom, teacher, student case studies
  - Phenomenology
  - Discourse analysis
  - Think aloud protocols